MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023 (TERM ID 2250)

ETM7156 – MOBILE WIRELESS COMMUNICATIONS

(M.Eng.Tele)

4 JULY 2023
10.30 a.m. – 1.30 p.m.
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This examination paper consists of 7 **printed pages** (including the cover page) with **5 questions only.**

2. **Attempt ALL questions.** All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided. **Show all relevant steps** to obtain maximum marks.

QUESTION 1

(a) (i) With the aid of a diagram, briefly describe the working principle of a cellular network. [6 marks]

(ii) Draw a diagram to depict the spectrum allocation for three cells and the placement of a base station site in a 4G Long-Term Evolution (LTE) cellular network that employs a frequency reuse factor of one and a directional antenna with 120° sectorization. [3 marks]

(iii) The signal-to-interference ratio (SIR) of a cellular network with cluster size N can be approximated by the following equation:

$$\frac{S}{I} = \frac{\left(\sqrt{3N}\right)^n}{i_0}$$

where i_0 is the number of co-channel interfering cells, n is the path loss exponent. Subjective tests indicate that satisfactory voice quality is achieved when SIR is at least 15 dB. Assuming $n = 3$, $i_0 = 6$, determine the cluster size N. [2 marks]

(iv) For a 4G LTE cellular network that is designed for packet switched data transmission, explain how analog voice calls can be made. [3 marks]

(b) A blocked-calls-cleared based cellular system has a total bandwidth of 25.2 MHz and each duplex channel requires 30 kHz. Assume that each user produces 0.2 Erlangs of traffic and a frequency reuse factor of 1/12 is used. An Erlang B table is provided in Appendix 1.

(i) Determine the total number of duplex channels per cell. [2 marks]

(ii) Assume that each cell supports an amount of traffic intensity (in Erlangs) that is equivalent to 90% of the total number of duplex channels per cell. Calculate the number of users that can be accommodated in a cell, assuming that omnidirectional antennas are used at each base station. [2 marks]

(iii) Determine the blocking probability of the system in Question 1 (b)(ii). [2 marks]

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QUESTION 2

(a) (i) With the aid of a diagram, briefly describe the three basic propagation mechanisms in wireless communications. [5 marks]

(ii) Briefly describe the two major categories of factors influencing small-scale fading in both the time and frequency domains. [4 marks]

(b) (i) Briefly describe the purpose of conducting a link budget analysis of wireless communication systems. [3 marks]

(ii) Given the following parameters of a wireless link, express logarithmically the link budget equation for P_{RX}: [3 marks]

- P_{RX} - received power (dBm)
- P_{TX} - transmitter output power (dBm)
- G_{TX}, transmitter antenna gain (dBi)
- L_{TX}, transmitter losses (coax, connectors) (dB)
- L_{FS}, path loss, usually free space loss (dB)
- L_M, miscellaneous losses (fading margin, body loss, polarization mismatch, other losses) (dB)
- G_{RX}, receiver antenna gain (dBi)
- L_{RX}, receiver losses (coax, connectors) (dB)

(c) Figure Q2 shows bit error performance P_e curves due to degradation in signal to noise ratio under different fading channel conditions.

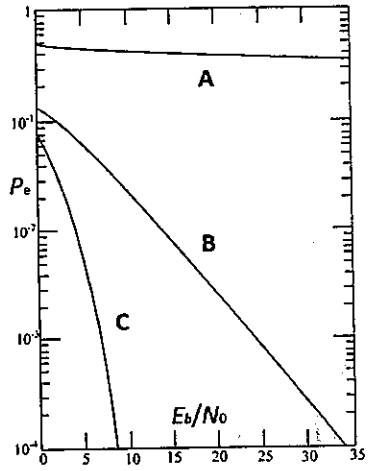

Fig. Q2

(i) State the three types of fading channels that result in the three P_e curves labelled A, B, and C, respectively. [3 marks]

(ii) Suggest the relevant techniques to reduce the effects of fading and improve the bit error performance from curve B to curve C. [2 marks]

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QUESTION 3

(a) Discuss the tradeoff between power efficiency and bandwidth efficiency for M-ary phase shift-keying (M-PSK) modulation with $M = 2$ and $M = 16$. [4 marks]

(b) (i) What are pilot signals and why they are used in wireless communication system? [2 marks]

(ii) Design and sketch a receiver for channel estimation and equalization in a communication system where a probing/pilot signal is multiplexed with an information-bearing signal in the transmitter before transmission over the channel. The receiver should consist of three sub-systems: demultiplexer, matched filter, and channel equalizer. Explain the working principle of the receiver using appropriate mathematical equations. [9 marks]

(c) Briefly explain the goal and working principle of adaptive modulation and coding (AMC) as a link adaptation technique in 4G LTE cellular networks. Explain the mechanism of AMC for the downlink of LTE. [5 marks]

Continued .....

QUESTION 4

(a) (i) Define the two major categories of channel equalizers for digital communication systems. [2 marks]

(ii) Sketch the structure of a linear transversal equalizer. [3 marks]

(iii) Briefly describe the two operating modes of an adaptive channel equalizer. [3 marks]

(b) The probability that the SNR of a received signal is less than threshold γ of an M-independent branch selection diversity receiver is given by the following theoretical formula:

$$P_M(\gamma) = \left(1 - e^{-\gamma/\Gamma}\right)^M$$

where M and Γ are constants. We define outage as the situation when the received SNR is less than 15 dB.

(i) Explain the principle of diversity in wireless communications. State four major types of diversity. [4 marks]

(ii) Determine the probability of outage when $M = 1$ and $\Gamma = 25$ dB. [2 marks]

(iii) Determine the value of M if we want to achieve a probability of outage of less than 1% for $\Gamma = 25$ dB. [2 marks]

(iv) If modifications are allowed at the signal processing block of a selection diversity receiver, suggest how this receiver should be modified to achieve further performance improvement without increasing the number of branches. [2 marks]

(iv) Practical measurements carried out by a researcher shows that the performance of an M-branch diversity receiver is poorer than that predicted by the theoretical formula given above. State a possible reason for the discrepancy. [2 marks]

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QUESTION 5

(a) Fig Q5 shows the logical separation of a Time Division Multiple Access/Time Division Duplex (TDMA/TDD) transmission system.

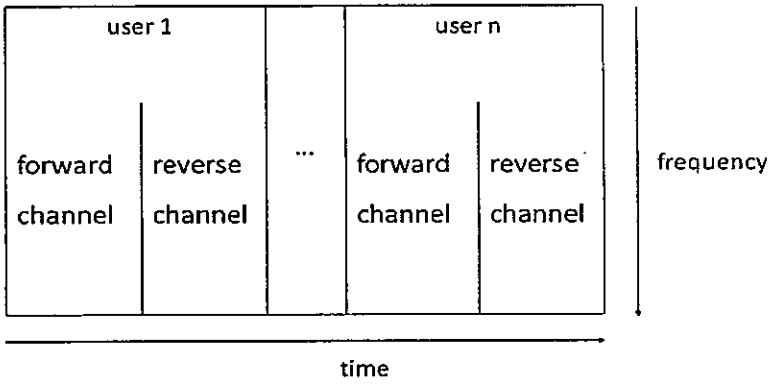


Fig. Q5

Using similar format, draw the logical separation diagram of the following transmission systems:

(i) Frequency Division Multiple Access/Frequency Division Duplex (FDMA/TDD). [2 marks]

(ii) FDMA/TDD. [2 marks]

(iii) TDMA/FDD) [2 marks]

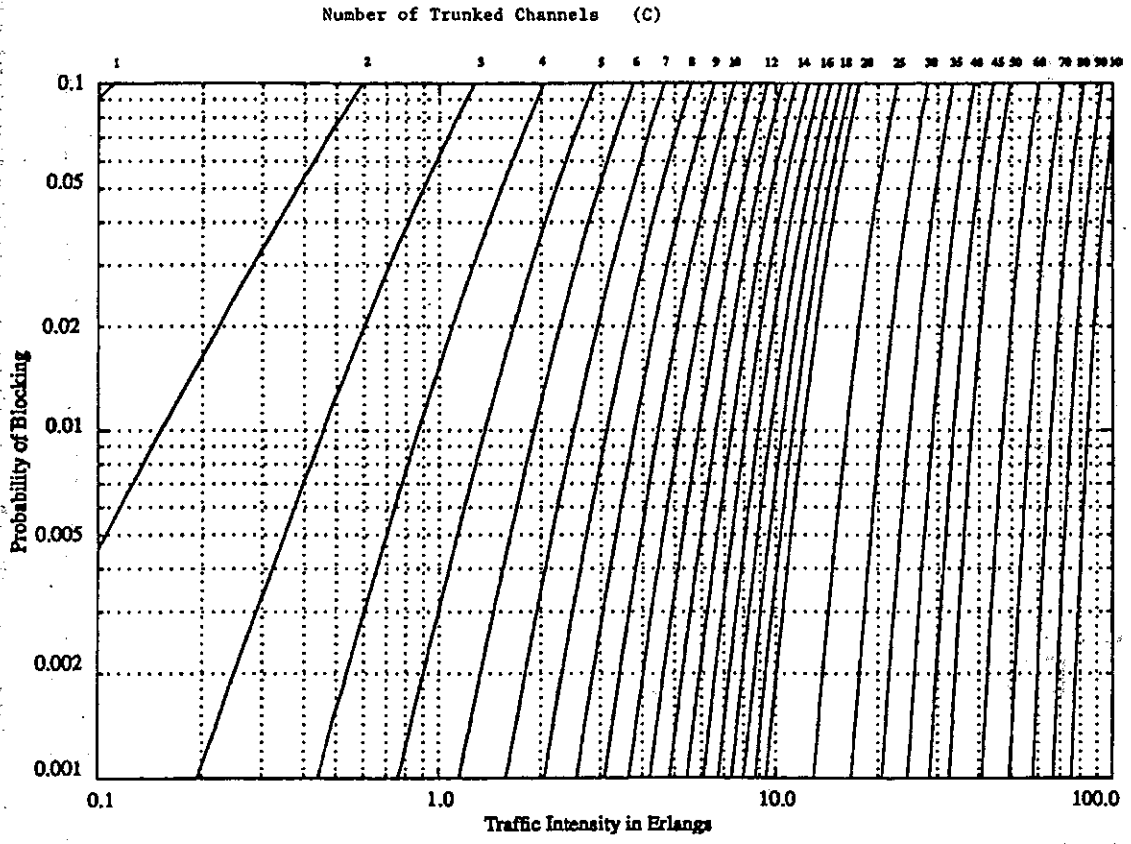
(b) Briefly describe the mechanism and functionality of channel dependent scheduling in 4G LTE cellular networks. [6 marks]

(c) (i) What is scalable 5G New Radio (NR) orthogonal frequency division multiplexing (OFDM) numerology, and what is its role in 5G communication systems? [3 marks]

(ii) In general, how can an appropriate numerology be chosen for a given 5G NR deployment scenario? Explain your answer using hotspot areas and rural areas as examples. [5 marks]

End of Questions

Appendix: Erlang B Table



End of Paper